USERS OF MIDDLE ATMOSPHERE MODELS
REMARKS

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The procedure followed for shuttle operations is to calculate descent trajectories for each potential shuttle landing site using the Global Reference Atmosphere Model (GRAM) to interactively compute density along the flight path 100 times to bound the statistics. The purpose is to analyze the flight dynamics, along with calculations of heat loads during re-entry. The analysis program makes use of the modified version of the Jacchia-70 atmosphere, which includes He bulges over the poles and seasonal latitude variations at lower altitudes. For the troposphere, the 4-D model is used up to 20 km, Groves from 30 km up to 90 km. It is extrapolated over the globe and faired into the Jacchia atmosphere between 90 and 115 km. Since data on the Southern Hemisphere was lacking, what was done was that the data was flipped over and lagged 6 months. Remarkably, this procedure seems to work quite well.

Sometimes when winds are calculated from pressure data in the model there appear to be discontinuities. Modelers indicated that the GRAM was not designed to produce winds, but good wind data is needed for the landing phase of shuttle operations. It was remarked that use of atmospheric models during re-entry is one application where it is obvious that a single integrated atmosphere model is required.

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USERS SESSION

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EMPHASIS OF SESSION

- HOW MODELS ARE BEING UTILIZED (JSC EMPHASIS IS ON GRAM)
- MODEL CHARACTERISTICS THAT ARE POSING POTENTIAL PROBLEMS TO TRAJECTORY CONTROL
- SENSITIVITY TO ATMOSPHERIC PERTURBATIONS, DEFINITION OF CRITICAL AREAS

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AGENDA

- OVERVIEW OF JSC GRAM ACTIVITIES
- SPACE SHUTTLE APPLICATIONS - KENT JOOSTEN/JSC, STEVE MCCARTY/MDC
- AOTV APPLICATIONS - OLIVER HILL/JSC
- CORRELATION WITH SHUTTLE DATA, AOTV IMPLICATIONS - JOE GAMBLE/JSC
- OTHER PREPARED COMMENTS
- OPEN DISCUSSION
- SPACE SHUTTLE RESULTS - JOHN FINDLAY/FLIGHT MECHANICS AND CONTROL

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OVERVIEW OF JSC GRAM ACTIVITIES

- GRAM IS BEING UTILIZED BY SEVERAL JSC ORGANIZATIONS
  - MISSION OPERATIONS DIRECTORATE - SHUTTLE ENTRY SIMULATIONS
  - MISSION SUPPORT DIRECTORATE - AOTV ANALYSIS
  - ENGINEERING DIRECTORATE - CORRELATION WITH SHUTTLE RESULTS, APPLICATION TO AOTV

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CORRELATION WITH SHUTTLE ENTRY DATA/AOTV CONCERNS

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- JSC ADVANCED PROGRAMS OFFICE HAS A THREE YEAR RTOP TO INVESTIGATE THE ATMOSPHERIC DENSITY DERIVED FROM THE SHUTTLE ENTRY FLIGHTS.
  - NATIONAL WEATHER SERVICE IS COORDINATING A SOUNDING ROCKET PROGRAM ALONG THE SHUTTLE ENTRY TRACK AND PROVIDING THEIR BEST ESTIMATE OF THE ATMOSPHERIC PROPERTIES FOR THE ENTRY PROFILE.
  - JOHN FINDLAY OF FLIGHT MECHANICS AND CONTROL IS PROVIDING ANALYSIS OF THE ENTRY DATA
- GRAM IS BEING UTILIZED FOR SIMULATIONS FOR AOTV PROGRAM
  - GRAM IS TIED INTO THE SIMULATION REAL TIME RATHER THAN FIRST GENERATING A ATMOSPHERE PROFILE OFF LINE FOR LATER USE IN THE SIMULATION.

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SUMMARY

- GRAM RESULTS APPEAR CAPABLE OF REPRODUCING DENSITY PROFILES OBSERVED DURING THE SHUTTLE ENTRY FLIGHTS
  - PRIMARY CONCERN IS ABOUT THE CONFIDENCE IN THE STATISTICS OF THE GRAM RANDOM PERTURBATION MODEL. I.E. IS THE 3-SIGMA CASE REALLY 3-SIGMA,2.5-SIGMA,3.5-SIGMA
- MAGNITUDE OF DENSITY GRADIENTS ARE A MAJOR CONCERN FOR THE AOTV
  - CURRENT PRELIMINARY DESIGN EFFORTS ARE CONSIDERING MAXIMUM GRADIENTS OF 20-30% OCCURING OVER 1-3 KM ALTITUDE
  - LATITUDE EFFECTS ARE CRITICAL TO THE AOTV - IF DENSITY GRADIENTS OBSERVED AT MORE NOTHERN LATITUDES WERE POSSIBLE AT THE LOWER LATITUDES, THE DESIGN OF THE AOTV COULD BE SIGNIFICANTLY EFFECTED

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- CORRELATION OF GRAM WITH SHUTTLE ENTRY RESULTS

  - IN A SERIES OF 20-50 GRAM RANDOM PERTURBATION RUNS IN THE 30-90 KM ALTITUDE RANGE, AT LEAST ONE RUN WILL YIELD DENSITY CHARACTERISTICS SIMILAR TO THOSE OBSERVED DURING THE SHUTTLE ENTRY. (QUALITATIVE EVALUATION)

  - THE SHUTTLE DEVIATIONS FROM MODEL MEAN VALUES (62,76 STD) WILL ALWAYS BE EXCEEDED BY THE ENVELOPE RESULTING FROM A SERIES OF GRAM RUNS.

  - THE AMPLITUDE OF SHUTTLE OBSERVED DENSITY GRADIENTS WILL ALWAYS BE EXCEEDED DURING A SERIES OF GRAM RUNS.

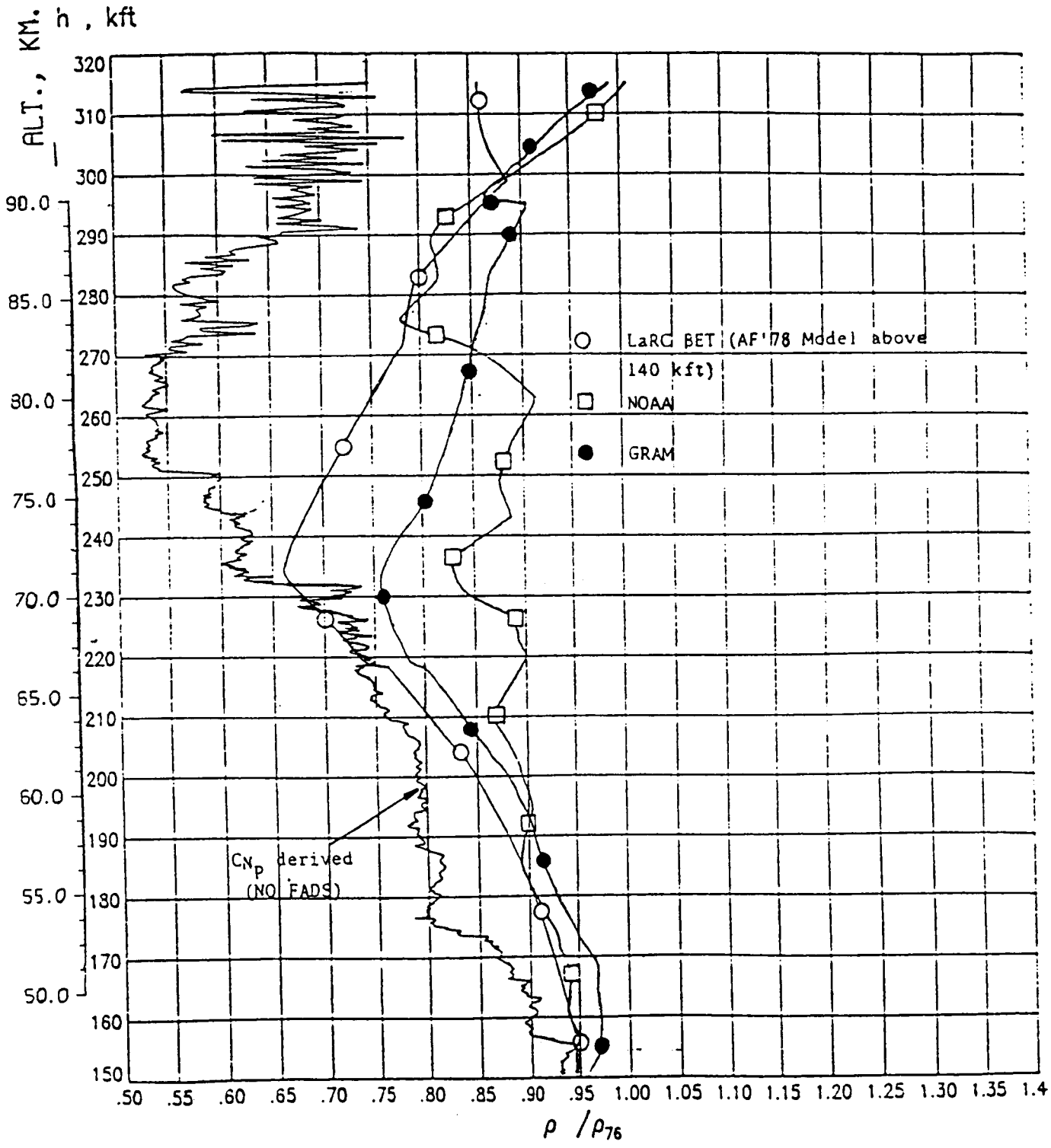
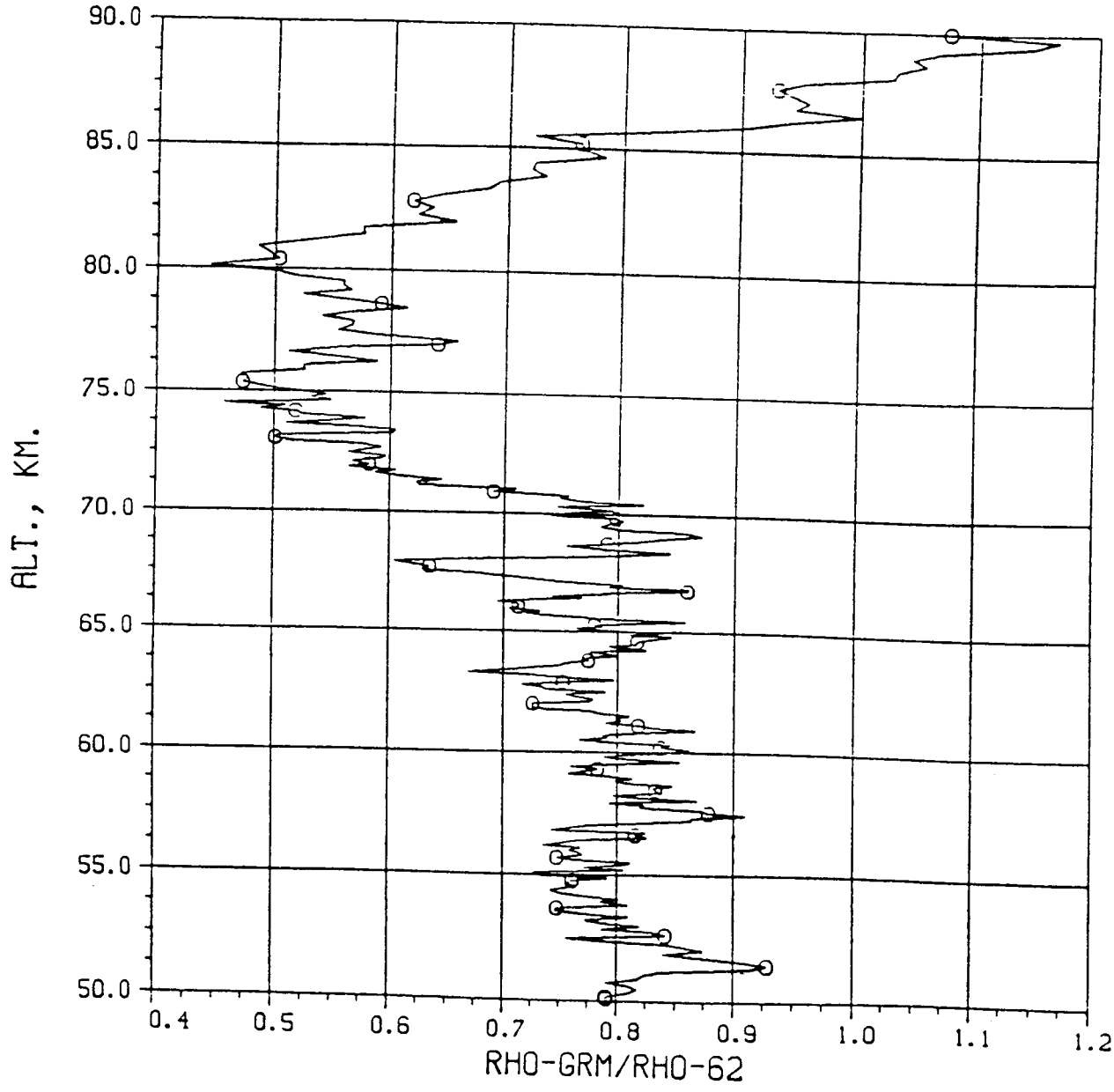


Figure A-9. STS-9 (December) density comparisons

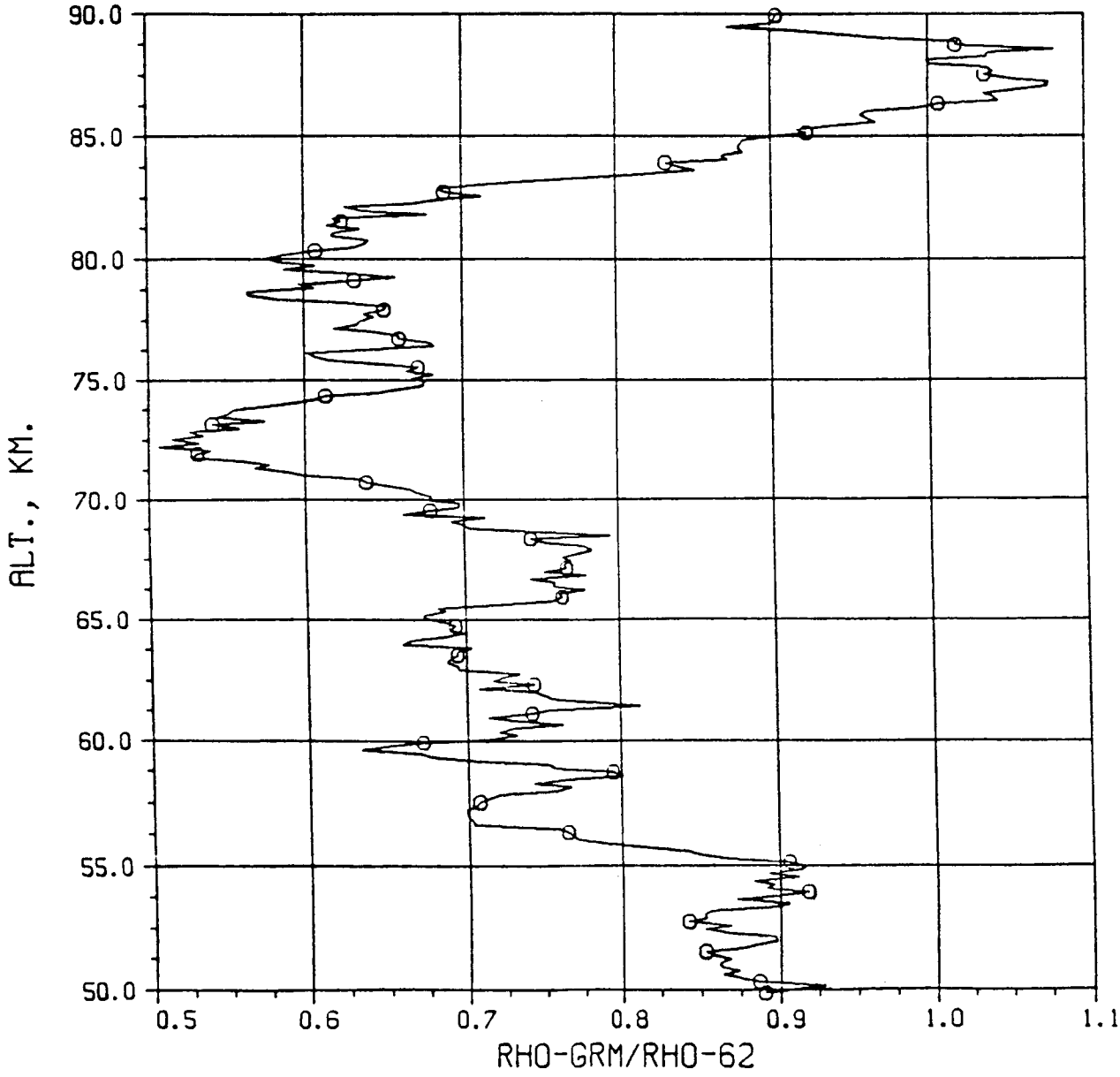
STS-9 GRAM Simulation

December -57° Latitude



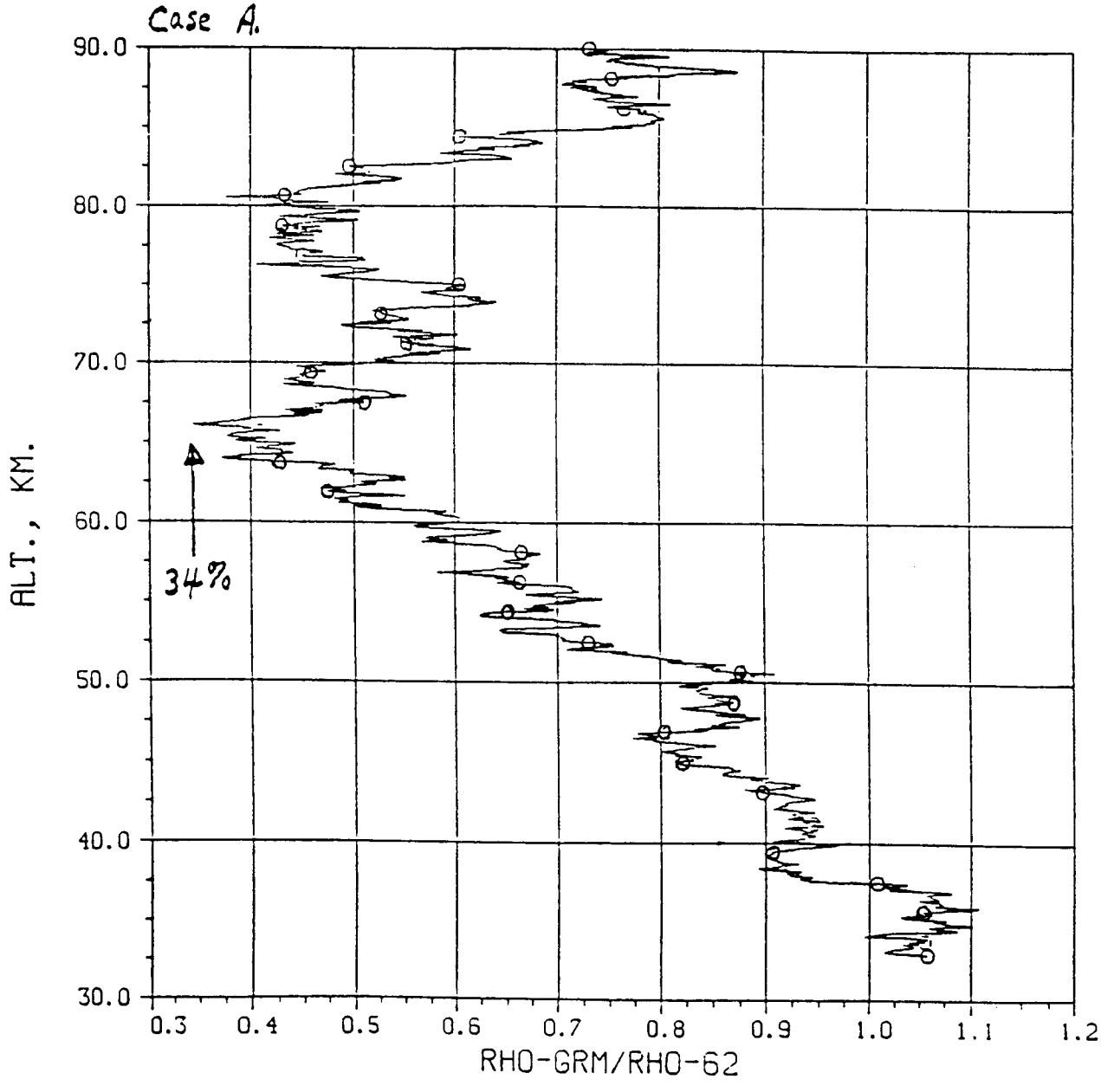
STS-9 GRAM Simulation

December - 57° Latitude



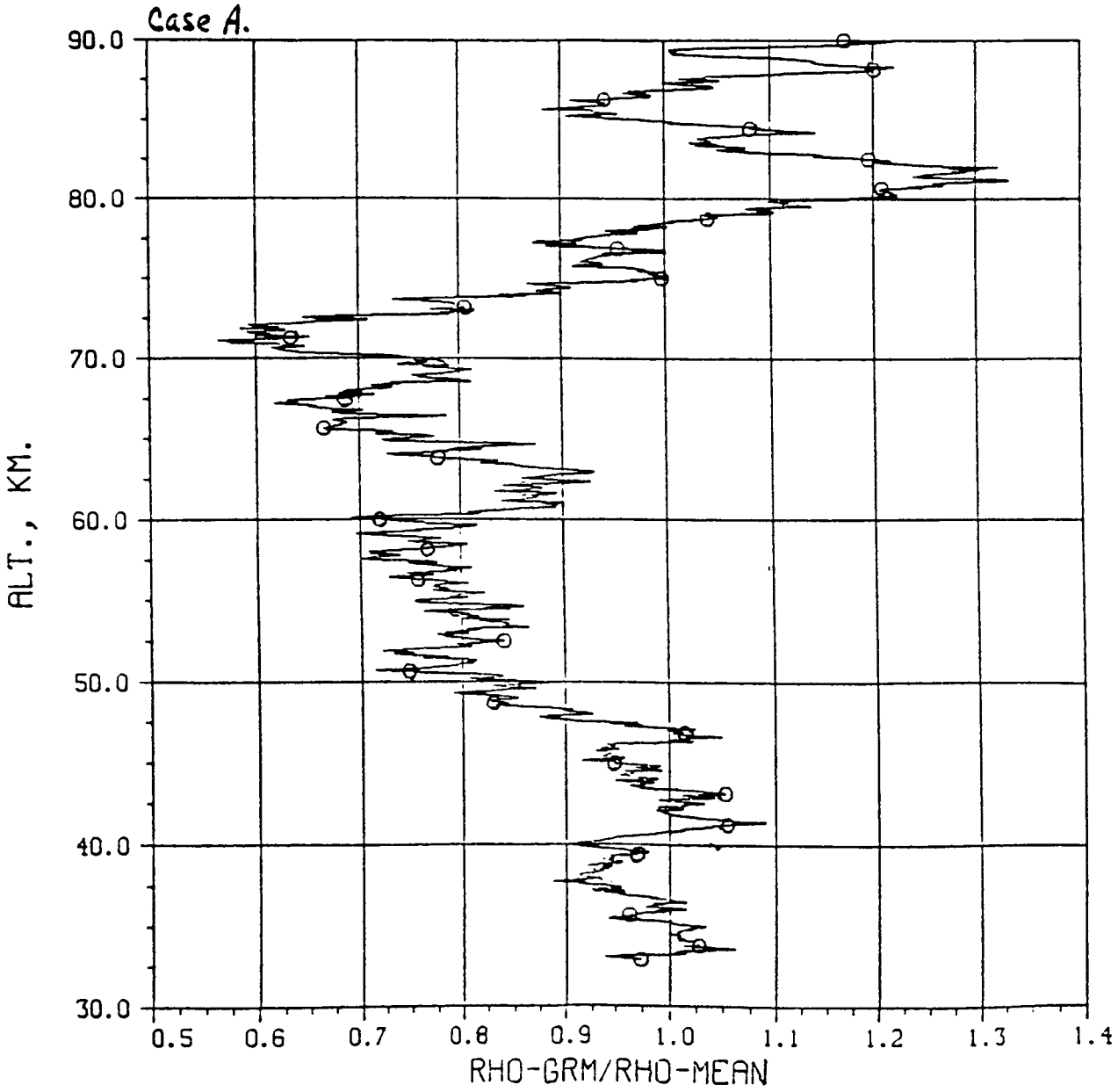
STS-9 GRAM Simulation

December - 57° Latitude



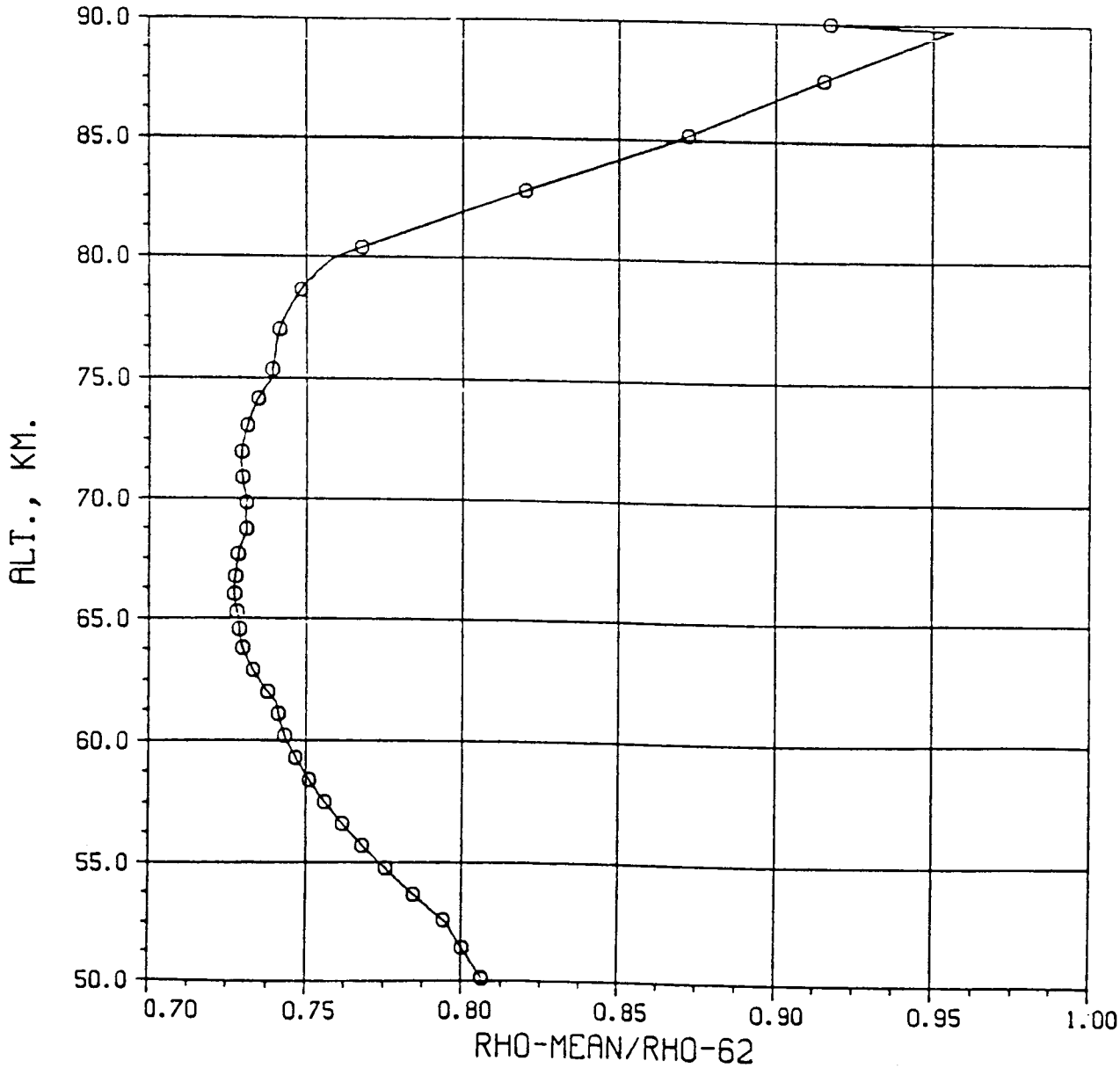
STS-9 GRAM Simulation

December - 57° Latitude



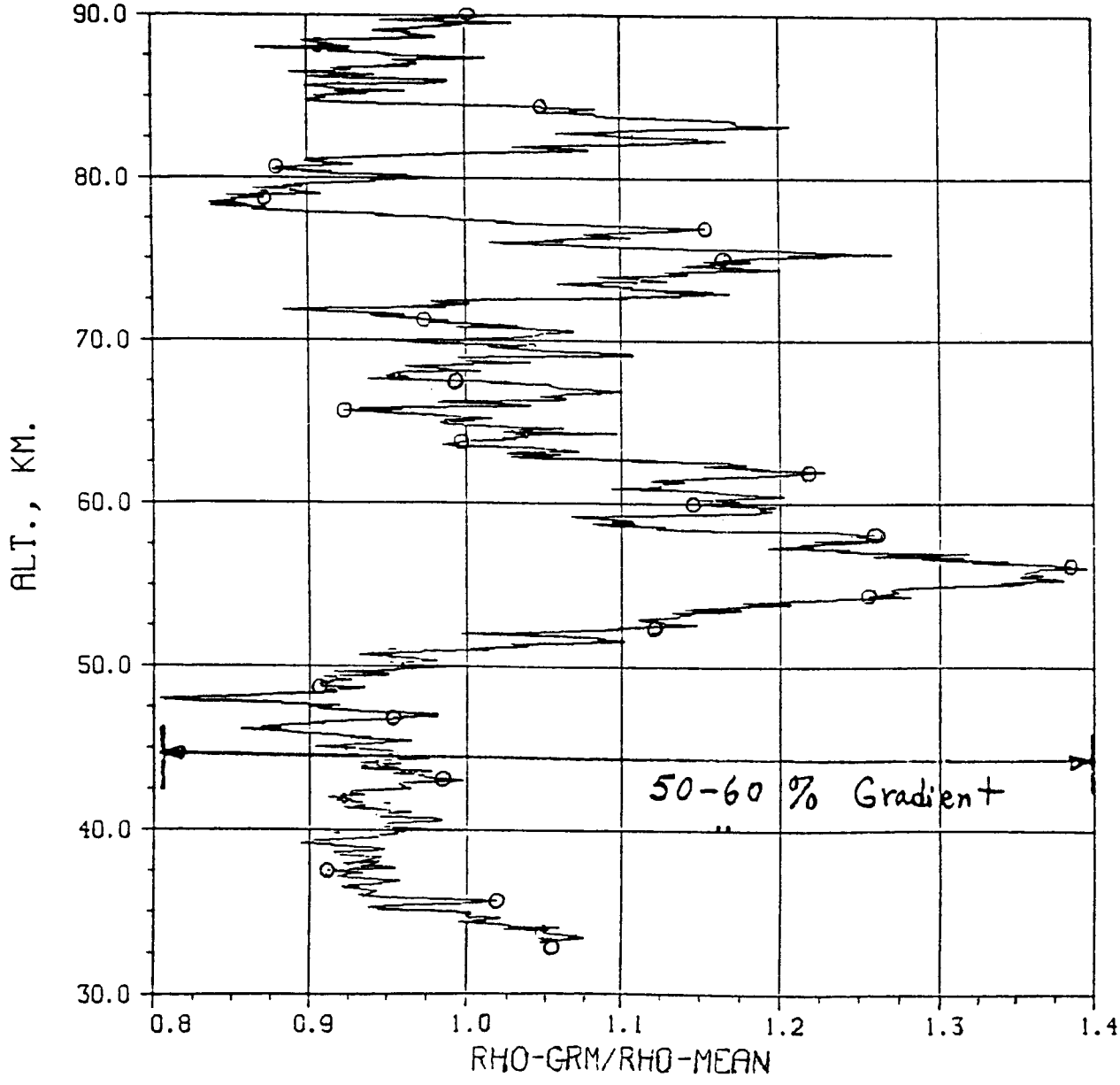
STS-9 GRAM Simulation

December - 57° Latitude



STS-9 GRAM Simulation

December - 57° Latitude



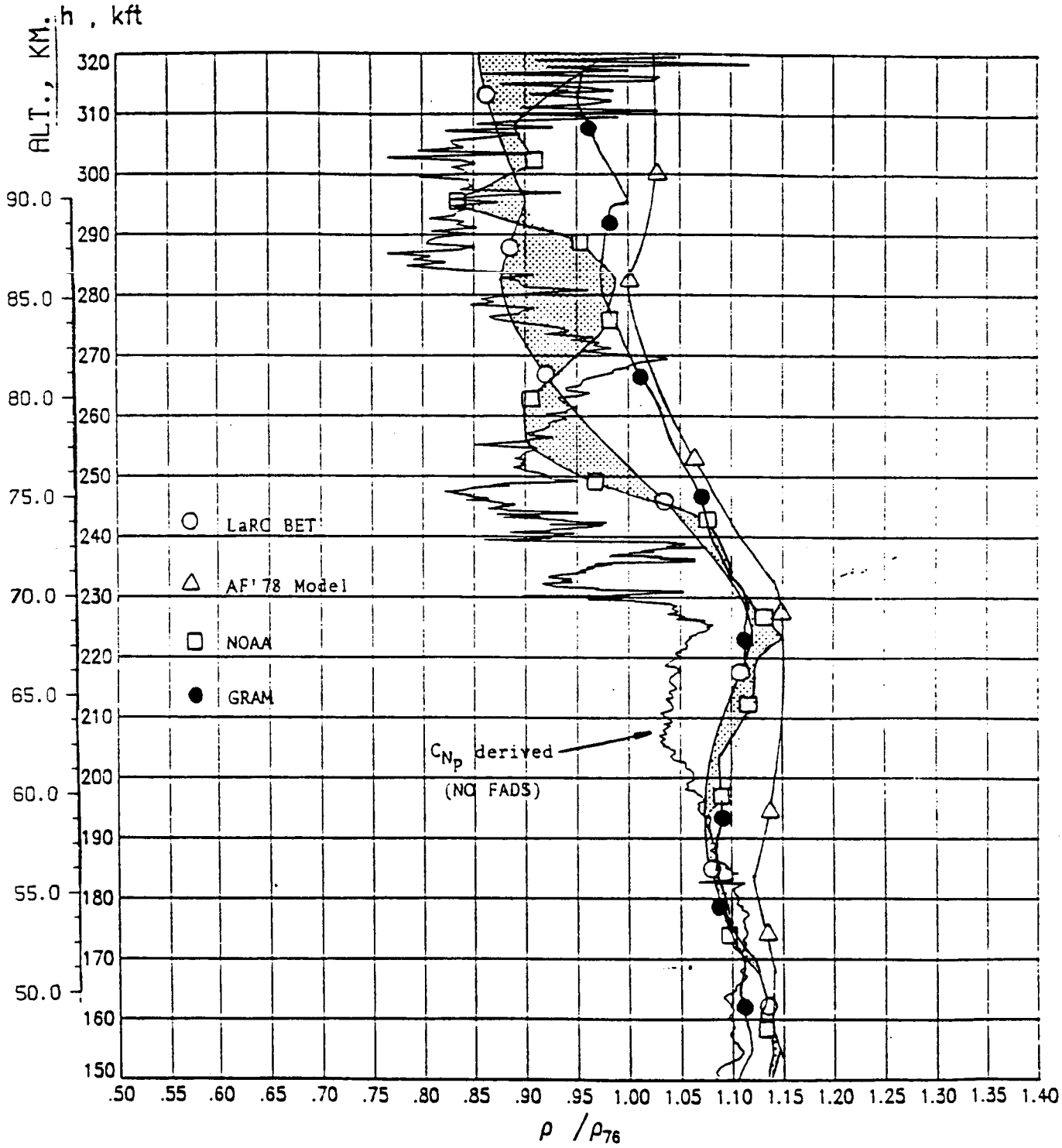
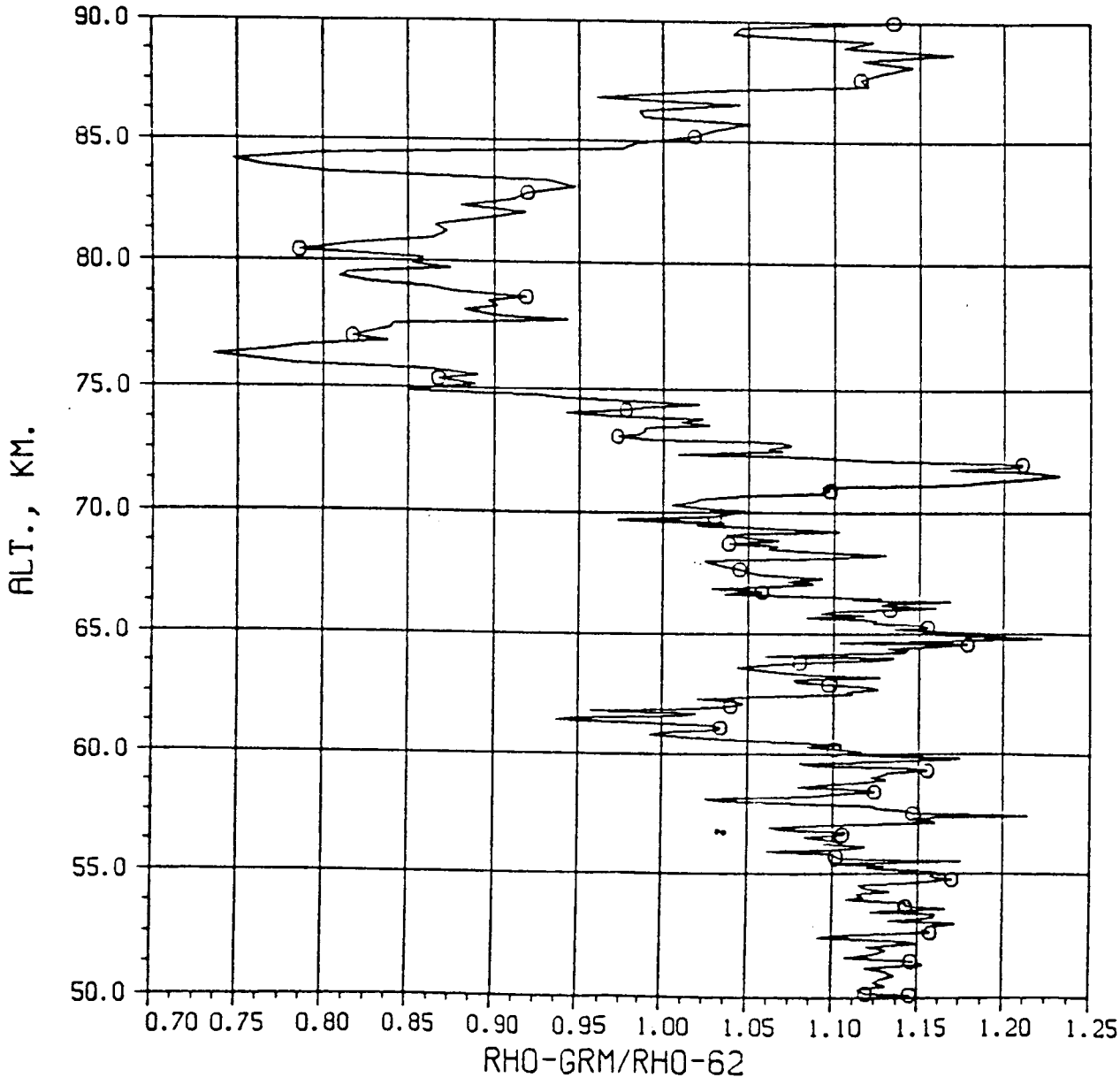


Figure A-4. STS-4 (July) density comparisons -29-

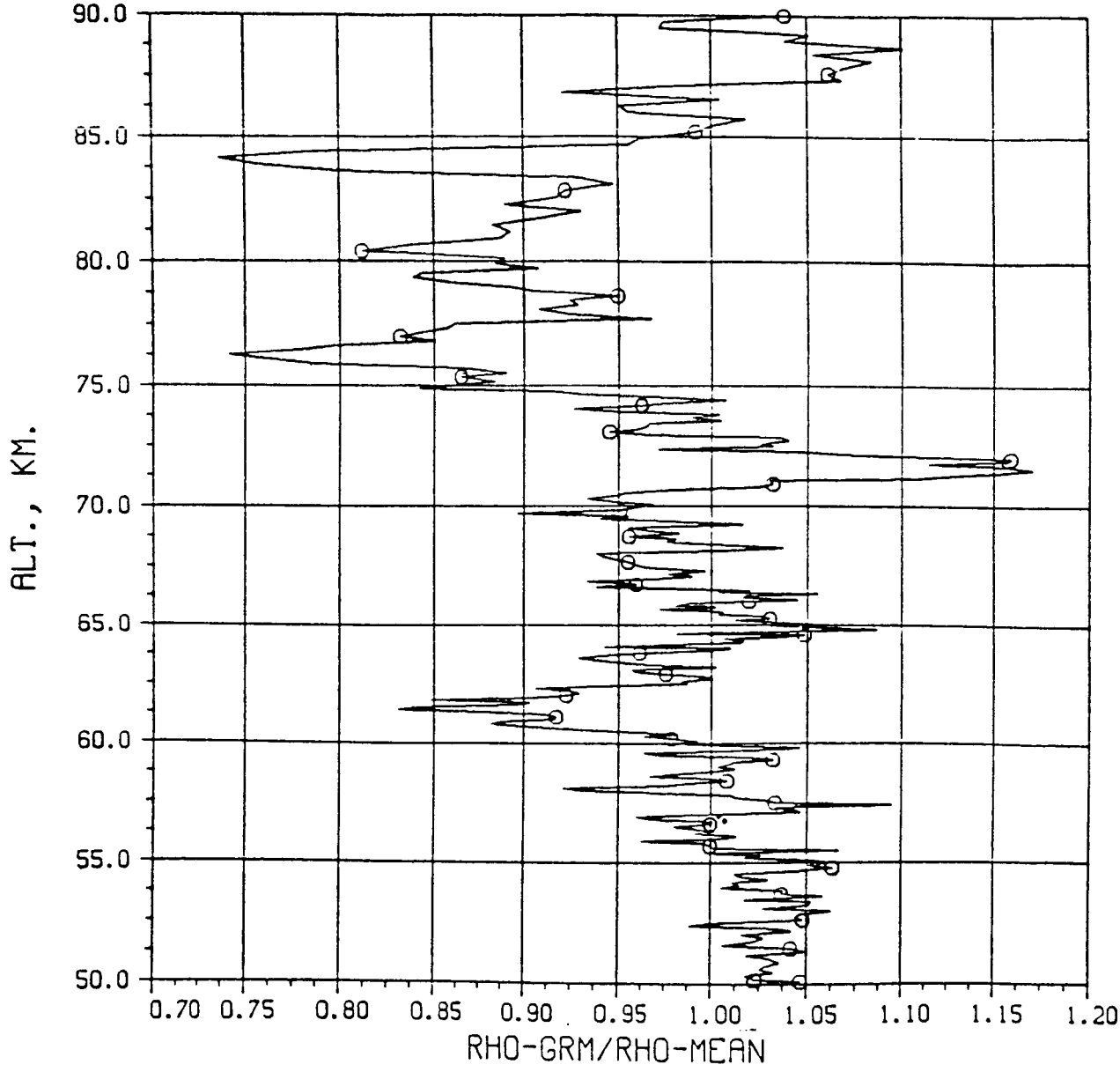
STS-4 GRAM Simulation

July- 25-30° Latitude



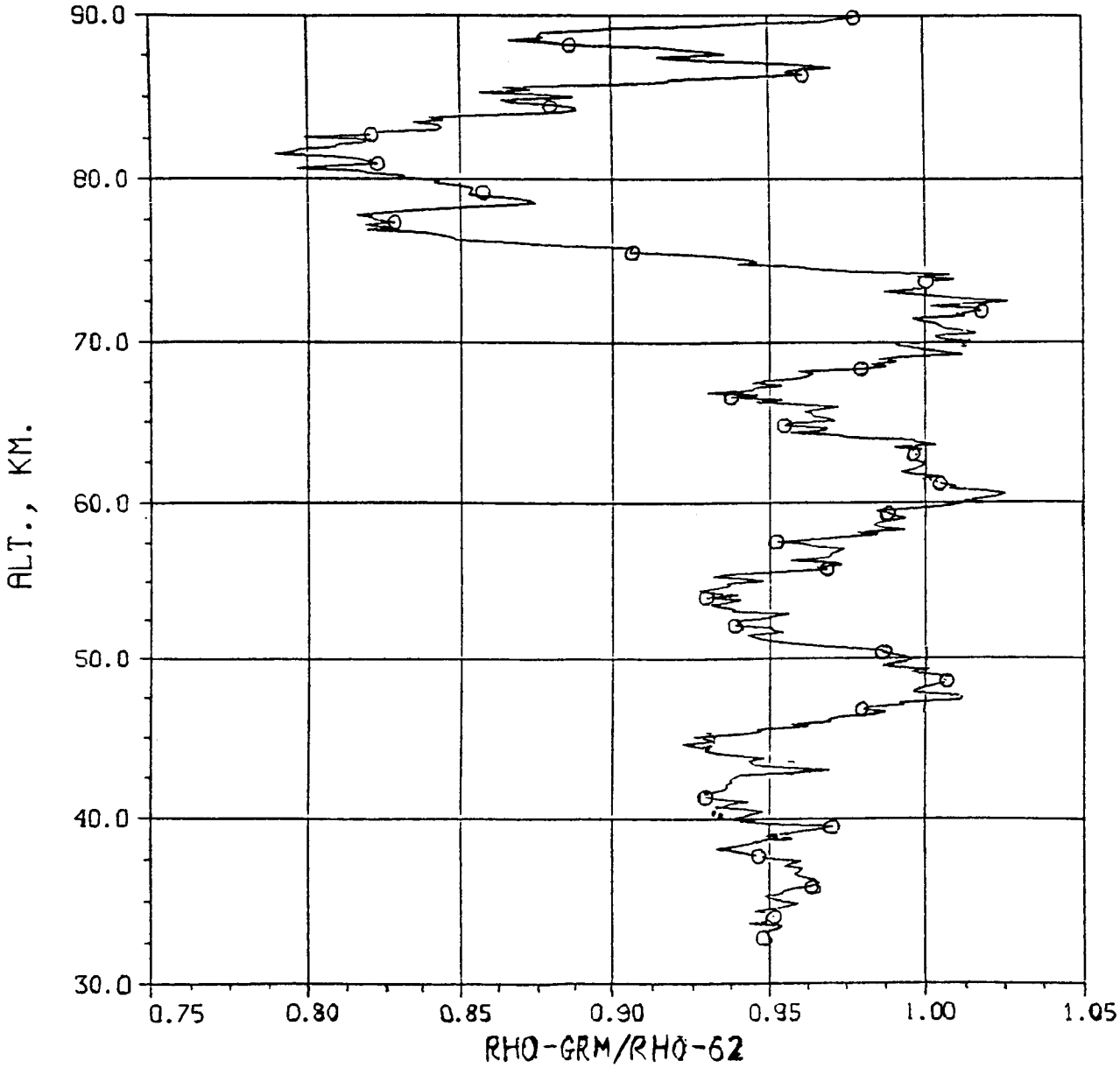
STS-4 GRAM Simulation

July - 25-30° Latitude



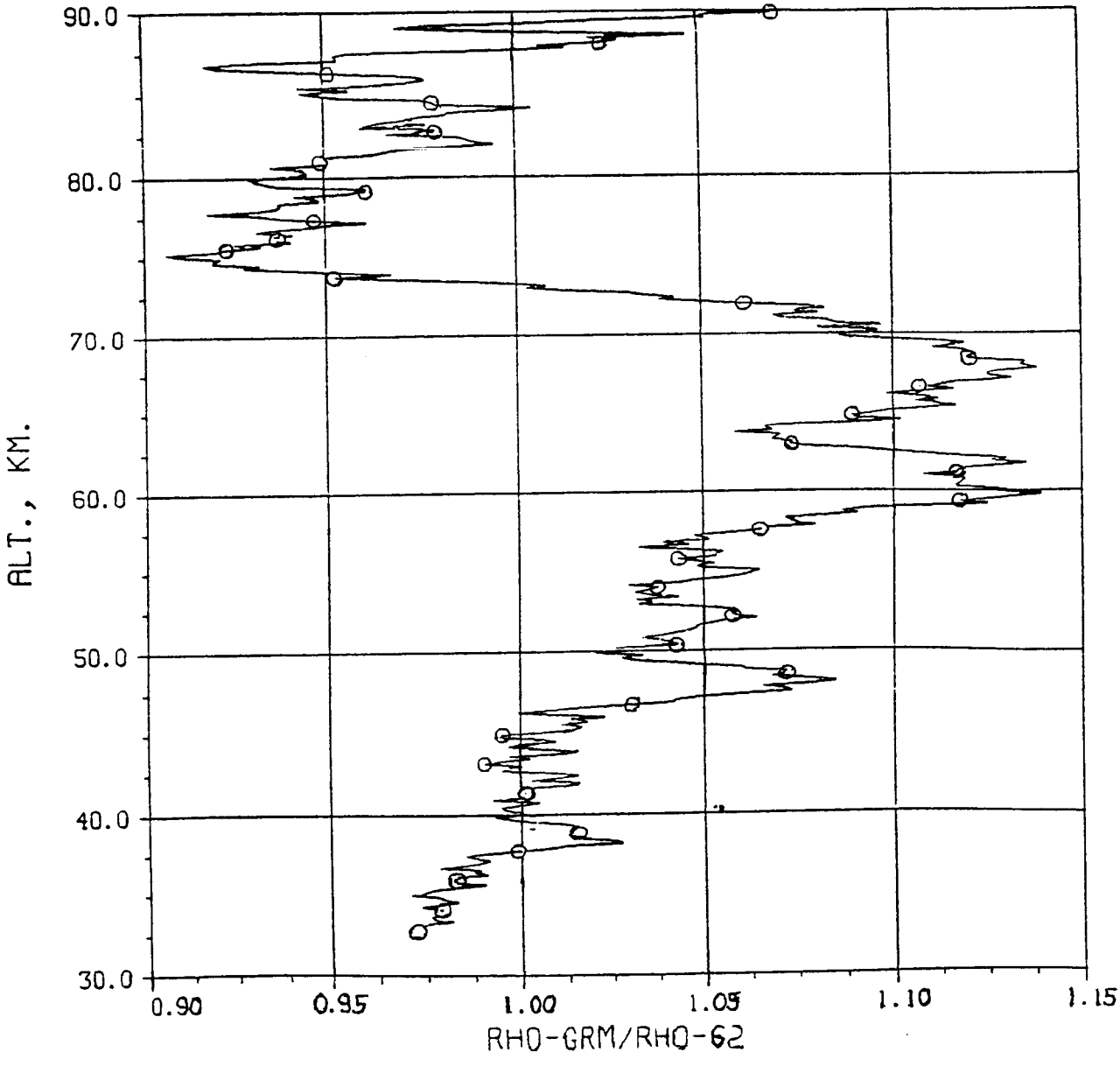
EARLY AOTV

January - 10° Latitude



EARLY AOTV

January - 10° Latitude



GRAM RANDOM PERTURBATIONS